The IAI Robot Control System in Researching Phone Speaker Production Lines

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ABSTRACT

This article presents research on the IAI Robot control system in a phone speaker production line being operated in Vietnam. In assembly and handling technology, electric actuators are used for linear, rotary, or clamping movements. Single-axis IAI robots become flexible when paired together. IAI robots (Intelligent Actuators) meet significantly high requirements in terms of payload, speed, and travel length. The IAI Robot's control program is programmed on Keyence PLC and uses expansion modules to ensure the IAI Robot's stable operation, high accuracy, and fast processing speed. The results of research, construction, and direct experiments at the factory show that the system operates stably with high accuracy.

Keywords: Control Engineering; Automation; Phone's speaker production line; IAI Robot; PLC Keyence.

1. Introduction

Automation is a field that has been formed and developed widely around the world, contributing a large part to the creation of products of high quality and complexity to serve essential needs. in life [1],[2]. In our country, the field of automation has received great attention and investment from the Party and State, along with other industrial sectors to transform the economy towards industrialization - modernization of the country.

The supporting industry in Vietnam is growing strongly to research and manufacture machines and lines to serve the industry. Based on technical requirements, when manufacturing a line for a process or product, manufacturers of automatic machines or automatic lines will come up with a plan to design, manufacture as well as arrange the machines, robot, and the worker's standing position in the line [3]. Along the line, materials are put through the machining process to create a finished product; or machine parts and details move to the next stage to be assembled to make finished products.

The author's article studies the IAI Robot control system in the production of phone speakers on the SK Line A9 line. The IAI robot is integrated into a wire that specializes in producing phone speakers. IAI Robots when paired together are very flexible, the controllers can allow customization of position, speed, acceleration, torque, etc. [4], [5]. IAI robots can connect to PLCs via communication networks industry with high reliability [6]. The IAI Robot system control program is programmed on PLC Keyence [7], [8].

2. Phone speaker production process

The phone speaker production line integrating automation technology includes 24 processes linked together by Servo and Cylinder Transfer transport systems as shown in Figures 1 and 2.

- Cluster A1 – A24: Move Jig from cluster A24 to cluster A1. After the conveyor belt is controlled by the Servo motor to the operating position, the Sensor confirms that there is a Jig in the A24 On position, the Sensor confirms that the Jig is in the A1 Off position → The up and down cylinder will go down → The Jig clamping cylinder is

clamped. → Up and down cylinder goes up → Transfer cylinder moves the clamped Jig from position A24 to position A1 → Up and down cylinder goes down → Clamp cylinder releases the clamp to drop the Jig onto the conveyor belt → Up and down cylinder goes up

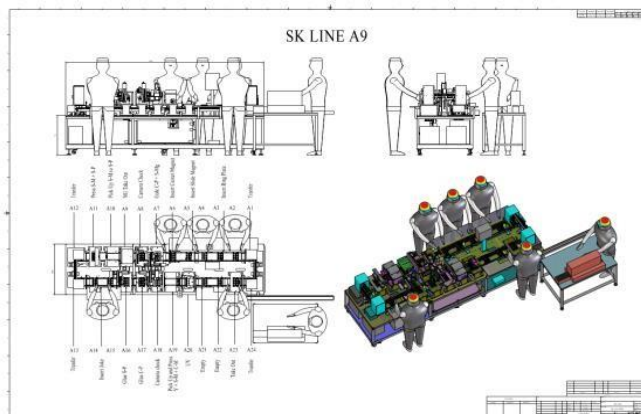→ Transfer cylinder moves from position A1 to position A24 to wait for the next step.

Figure 1. SK Line A9 principle drawing

Figure 2. Actual photo of SK Line A9 production line

- Cluster A2 – A3: Workers supply Ring Plate to Jig. After the conveyor belt is controlled by the Servo motor to the operating position, if there is a Jig at the product installation location, the worker will install 4 Ring Plates into the Jig so that the product is flat, without channels.

- Cluster A4- A5: Workers feed Slide Magnet into Jig. After the conveyor belt is controlled by the Servo motor to the operating position, if there is a Jig at the product installation location, the worker will install 8 Slide Magnets into the Jig so that the product is flat and free of channels.

- Cluster A6: Workers level Center Magnet into Jig. After the conveyor belt is controlled by the Servo motor to the operating position, if there is a Jig at the product installation location, the worker will install 4 Center Magnets into the Jig so that the product is flat and free of channels.

- Cluster A7: Apply glue to the two edges of the Ring Plate. After the conveyor belt is controlled by the Servo motor to the operating position → The Backup Cylinder lifts → The 3-axis X, Y, and Z robot will be controlled to apply glue to the 2 edges of the Ring Plate → After completing the Backup Cylinder lowers down.

- Cluster A8: Check the glue applied through cluster A7. After the conveyor belt is controlled by the Servo motor to the operating position → Backup cylinder lifts → 1-axis robot combined with Camera Check takes photos of 4 positions to compare photos of the glue line after passing A7 and the line Glue the sample to give the NG/OK signal to the PLC → After completion, the Backup Cylinder lowers.

- Cluster A9: Suck the defective glue product into the defective product tray. After the conveyor belt is controlled by the Servo motor to the operating position, if all products meet the requirements after passing through the Camera Check A8 cluster, the A9 cluster will not operate. If any product is detected as defective → Cylinder Backup lifts → Up and down cylinder goes down → Turn on the electromagnet at the position with the defective product → Support cylinder goes up to help separate the product from the Jig → Support cylinder goes down → Up and down cylinder goes up → Moving cylinder move forward → Turn off the Electromagnet to drop the defective product into the tray → Cylinder moves back and Backup Cylinder lowers.

- Cluster A10: Attract 2 Slide Magnets and place them in the glued position of the Ring Plate. After the conveyor belt is controlled by the Servo motor to the operating position, if all products do not meet the requirements, the A10 cluster will not operate. If any products meet the requirements → Backup cylinder lifts → Cylinder goes up and down. down → Turn on vacuum at the position where the product meets the requirements → Support cylinder goes up to help separate the product from the Jig → Up and down cylinder goes up at the same time Support cylinder goes down → Cylinder moves back → Cylinder up down and down → Turn off the vacuum and press the two products together → Up and down cylinder goes up → The cylinder moves to the waiting position and the Backup cylinder lowers.

- Assembly A11: Press the Slide Magnet and Ring Plate together after applying glue and placing them on top of each other to form a Slide Plate. After the conveyor belt is controlled by the Servo motor to the operating position, if all products do not meet the requirements, cluster A11 will not operate, if any products meet the requirements.

→ Backup Cylinder raises → Pressing Cylinder goes down to press the product together → After completion, Backup Cylinder lowers.

- Cluster A12 – A13: Move Jig from cluster A12 to cluster A13.

- Cluster A14 – A15: Workers supply Yoke to Jig. After the conveyor belt is controlled by the Servo motor to the operating position, if there is a Jig at the product installation location, the worker will install 4 Yokes into the Jig so that the product is flat and not crooked.

- Cluster A16: Apply Slide Plate glue. After the conveyor belt is controlled by the Servo motor to the operating position → The Backup Cylinder lifts → The 3-axis robot When completed, the Backup Cylinder lowers.

- Cluster A17: Apply Center Magnet glue. After the conveyor belt is controlled by the Servo motor to the operating position → The Backup Cylinder lifts → The 3-axis robot Once completed, the Backup Cylinder lowers.

- Cluster A18: Check the glue applied through clusters A16 and A17. After the conveyor belt is controlled by the Servo motor to the operating position → Backup cylinder lifts → 1-axis robot combined with Camera Check takes photos of 4 positions to compare photos of the glue line after passing A16 and A17 and the sample glue line to give the NG/OK signal to the PLC → After completion, the Backup Cylinder lowers.

- Cluster A19: Suction the Yoke and then press the Yoke onto the Slide Magnet and Center Magnet. After the conveyor belt is controlled by the Servo motor to the operating position, if all products do not meet the requirements, cluster A19 will not operate. If any products meet the requirements → Backup cylinder goes up → Pickup cylinder goes down in a position with a satisfactory product → Support cylinder goes up to help separate the product from the Jig → Turn on the vacuum in a position with a satisfactory product → Pickup cylinder goes up → Cylinder moves back → Cylinder Pickup goes down → Turns off vacuum → Pressing Cylinder in the position where the product meets the requirements goes up to press the product → Pressing Cylinder and Support Cylinder go down → Pickup Cylinder goes up → Cylinder moves to the waiting position When the Backup cylinder drops.

- Cluster A20: UV irradiation to dry glue. After the conveyor belt is controlled by the Servo motor to the operating position, if all products do not meet the requirements, the A20 cluster will not operate. If any products meet the requirements, 2 UV machines will irradiate the corresponding rays. products meet requirements.

- Cluster A21: Let dry naturally.

- Cluster A22: Let dry naturally

- Cluster A23: Take out the finished product to put it on the outside UV drying conveyor. After the conveyor is controlled by the Servo motor to the operating position → Backup cylinder lifts → Support cylinder goes up to help separate the product The product comes out of the Jig → The worker uses a jig with a magnet to attract the product and places it in the Jig to suck the product out → After completion, the Backup Cylinder lowers.

3. Equipment in the line

3.1. PLC Keyence

Because the line combines both manual and automation, a central controller is needed to control and connect the entire system. Therefore, using PLC Keyence as shown in Figure 3 is the central brain of the system, responsible for connecting and controlling the entire system [7], [8].
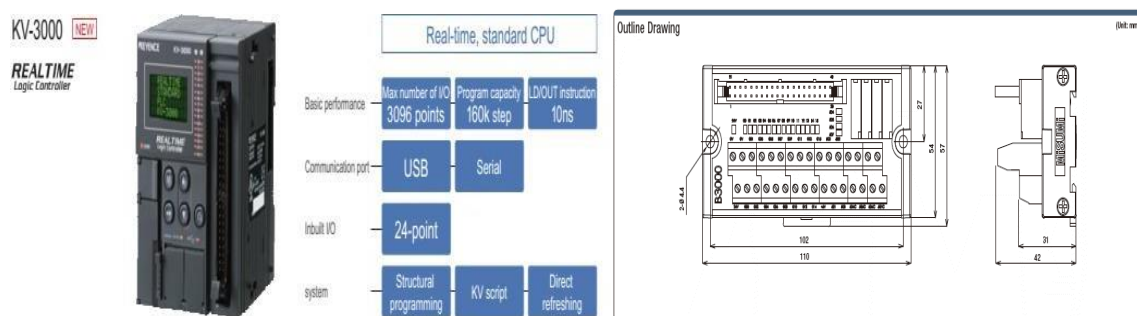

Figure 3. Keyence KV-3000 PLC

3.2. Omron Servo transport system

The line uses 2 Omron R88M-K20030H Servo motors as shown in Figure 4 with the control of 2 R88M-KT02H Driver sets to transport the Jig on the line. Each move is 280mm. OMNUC G5-series Servo Drive: Analog input/Pulse train input type, Capacity: 200W, 1-phase 200VAC power supply. Controlled by a high-speed pulse generator of PLC Keyence KV-3000, the highest pulse frequency is 100kHz.
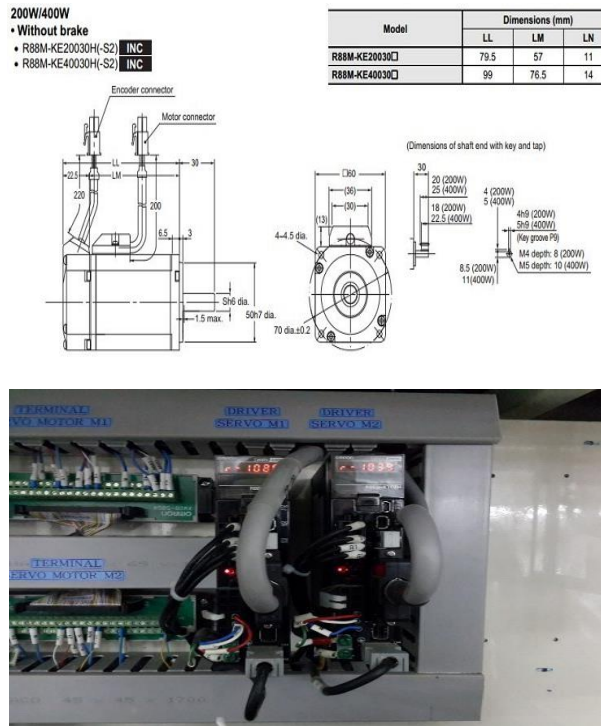
Figure 4. Servo controller in line

3.3. Robot IAI

3.3.1. Position of IAI Robot in the production line

The IAI robot is integrated into the glue application clusters A7, A16, A17, and Camera Check A8, and A18 of the line, ensuring it moves to the programming position accurately and at the required speed. With IAI Robot Check Camera clusters, it has the function of going to fixed Checkpoints, transmitting shooting signals to the PLC to process the shooting data and compare it with the standard data of the glue line. IAI Robot glue applicator clusters have the function of following the programmed glue path in combination with glue applicator machines to apply glue according to the desired profile on the product.

3.3.2. IAI robot with 1 axis cluster A8, A18

Camera Check cluster robot A8, A18 uses IAI code RCP3-SA3R-I-28P-4-200-P1-S-MR as shown in Figure 5: Running according to relative position, pulse motor, 4mm shaft head, travel Can move 200mm, comes with PCON controller using 24VDC voltage, motor cable and encoder cable are 3m long, motor is mounted on the right side of the moving shaft. IAI 1-axis robot cluster A8, A18 uses 1 Servo motor to control the axis, the robot is a sliding joint. There is an Encoder that responds to the position, speed, and direction of movement of the Robot

Figure 5. Image of Robot RCP3

3.4. Other actuator and control devices

- Glue applicator: In charge of applying glue to products for clusters A7, A16, A17.

- HOYA EXECURE 4000 UV light projector: Undertakes the UV light process to dry the glue after sticking the products together. Using 2-phase voltage 100-240 AC, power consumption 250W, using mercury bulbs, projection time 3000 hours, initial intensity 4000 mW/cm2.
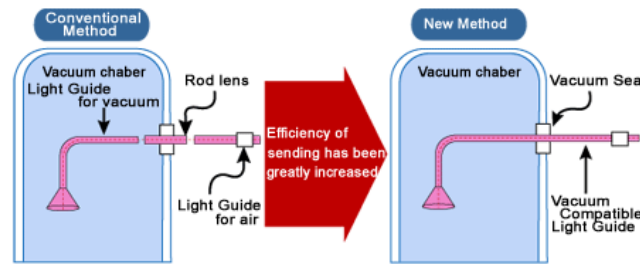

Figure 6. Original technology of HOYA EXECUTE 4000 UV projector

The adhesive can dry from a few seconds to several tens of seconds, depending on the UV irradiation conditions and the properties of the adhesive.
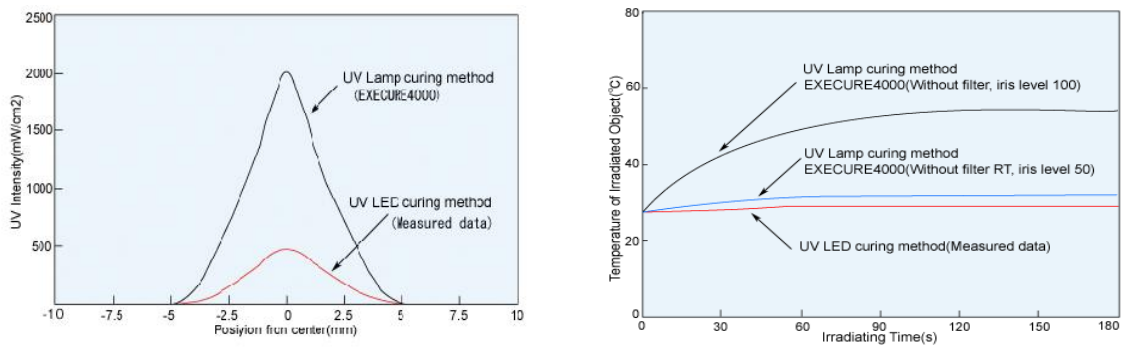

Figure 7. UV intensity and temperature increasing properties of the irradiated object

- Camera Keyence: Capture an image and compare it with the sample image to give an OK/NG (No Good) signal. Camera CV-035M is a monochrome camera with 310,000 pixels, shooting range of 640 x 480 pixels, transmission time of 16.7 ms. Using the CV-X100F controller: Can shoot 2 cameras simultaneously or separately, high-speed processor, capable of saving images.
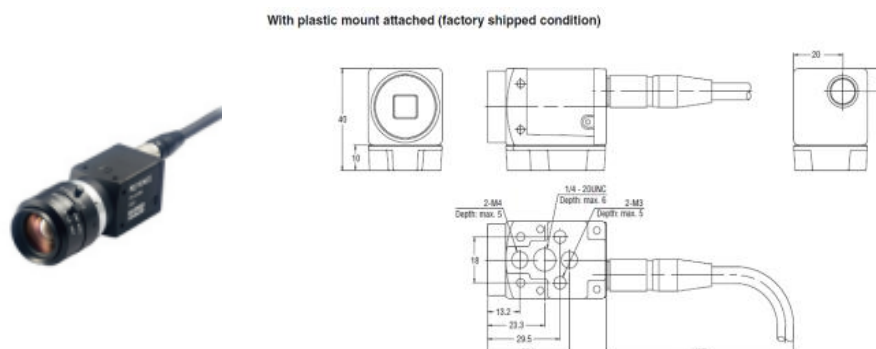

Figure 8. Camera Keyence CV -035

- Air Valve System: Air valves in the line mainly use valves from Mindman and SMC. Works best in the air pressure range of 0.4-0.6 Mpa. sed to control cylinders, supply air to glue pumps...
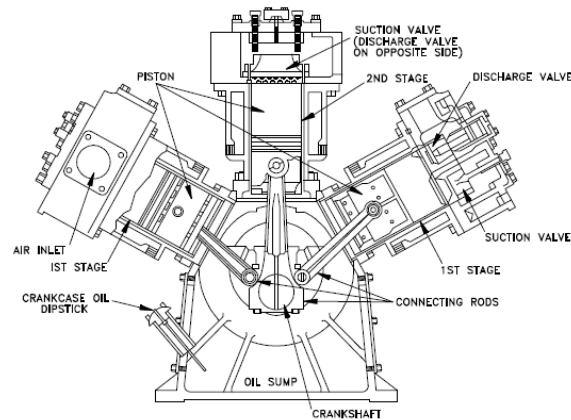

Figure 9. Robot technology has adopted pneumatic equipment

4. IAI Robot control system

The IAI Robot control system as shown in Figure 10 and Figure 11 is integrated in the line to take care of applying glue to products of clusters A7, A16, A17 (3-axis glue application combined between 2-axis IAI and 1-axis IAI), Camera Check clusters A8, A18 (IAI 1 axis) [9-15]. The horizontal axis can carry a maximum load of 6kg, and the vertical axis can carry a maximum load of 3kg. Maximum speed 300mm/s. The requirement of the IAI Robot in the production line is to move quickly and accurately according to the programmed trajectory, transmitting signals with the PLC Keyence to combine operations in the production line.

Figure 10. Image of IAI Robot

Figure 11. IAI Robot controllers in the production line

5. Conclusion

This article presents the phone speaker production process using the IAI Robot control system in the SK Line A9 production line. Products of the phone speaker production line are shown in Figure 12:

Figure 12. Actual products of SK Line A9 line

The phone speaker production process is based on the SK Line A9 line using the IAI Robot control system to help the line operate accurately according to the programmed trajectory, transmitting signals with PLC Keyence, and at the same time the single-axis IAI Robot when pairing. connect together to become flexible. IAI robots (Intelligent Actuators) meet significantly high requirements in terms of payload, speed, and stroke length, minimizing the frequency of failures and extending the effective operating time of technological equipment. The results of the research and construction steps after direct experiments at the factory show that the system operates stably with high accuracy.

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